Interagency Regional Monitoring

Northwest Forest Plan

Aquatic and Riparian Effectiveness Monitoring Program

2003 Annual Technical Report

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A copy of this report is also available on our Watershed Monitoring Website:
http://www.reo.gov/monitoring/watershed/

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

SUMMARY

The Aquatic and Riparian Effectiveness Monitoring Program (AREMP) was implemented in 30 sixth-field watersheds during 2003, our second year of monitoring. Funding limitations prevented us from meeting our 50-watershed goal. Highlights of the program include the following:

- We standardized protocols with the PacFish/InFish monitoring program – also known as PIBO – for site layout, pool definition, and gradient. We also examined the effects of how attributes are calculated and concluded: 1) Longitudinal profile data do not improve the accuracy or repeatability of our pool, gradient, or sinuosity measurements. Consequently, longitudinal profiles will no longer be measured, which should produce substantial time savings during field surveys. 2) Gradient, when calculated using the change in water surface elevation does not significantly differ from gradient calculated using the change in bed surface. Therefore, we will use water surface elevations to be consistent with PIBO and other monitoring programs. 3) We were unable to detect a relationship between pool tail fines and various particle size measurement metrics within sample sites, so we will continue to characterize substrate using both pool tail fines measurements and pebble counts.
- Decision support models were developed for each of the seven aquatic provinces that contain federal lands within the NWFP area. Over seventy people, representing seven federal and state agencies, participated in the development of the models. Evaluation curve values and indicator weights used in the models were developed and refined based on data, published literature, and professional judgment.
- Progress was made in developing a landslide assessment for use in decision support models. A workshop was held in which participants began developing an assessment protocol that will be implemented by the monitoring program in 2005.
- During the 2003 field season, 1 site in each of 28 watersheds was resurveyed as part of our quality assessment program. Results of the surveys showed general improvement in our ability to measure some attributes as well as suggesting areas for improvement. We also revised the field audit component of our quality assessment program.
- Eleven sites were resurveyed in 2003 that were sampled during 2002 for data quality assessments. Data from these sites will allow us to examine trends more quickly than waiting until all 250 watersheds are sampled before any repeat surveys are conducted.
- The watershed condition team leader continued to lead cooperative monitoring efforts – now known as the Pacific Northwest Aquatic Monitoring Partnership - between state, federal and tribal agencies within Washington, Oregon, California, and Idaho. Accomplishments included: several tribes joined the partnership; five different workgroups (steering committee, watershed condition monitoring, fish population monitoring, effectiveness monitoring, and data management) worked together to produce a planning document that identifies proposed coordination products, timelines, and budgets. The partnership efforts received strong support during “executive” briefings throughout the Pacific Northwest.
- The anticipated costs for fully implementing the monitoring plan, based on sampling an average of 6 sites for each of the 50 watersheds sampled each year, is about $4,364 for each sample site. This amount is slightly lower than past estimates because of the assumption we’ll be able to save money by hiring Student Conservation Volunteers for our field crews in 2004.

INTRODUCTION

Background

The Northwest Forest Plan (NWFP; hereafter referred to as “the Plan”) was approved in 1994. The Plan includes an Aquatic Conservation Strategy that requires the protection, rehabilitation, and monitoring of aquatic ecosystems under the Plan’s jurisdiction (USDA-USDI 1994). The Aquatic and Riparian Effectiveness Monitoring Plan (AREMP or the monitoring plan) was developed to fulfill these monitoring requirements. The objectives of the monitoring plan include assessment of the condition of aquatic, riparian, and upslope ecosystems at the watershed scale; development of ecosystem management decision support models to refine indicator interpretation; development of predictive models to improve the use of monitoring data; providing information for adaptive management by analyzing trends in watershed condition and identifying elements that result in poor watershed condition; and providing a framework for adaptive monitoring at the regional scale (Reeves et al. 2004). Monitoring is conducted at the subwatershed scale (USGS 6th-field hydrologic unit code). These subwatersheds (hereafter referred to as “watersheds”) are approximately 10,000-40,000 acres in size.

Collection of field data began summer 2000 in four watersheds (Gallo et al. 2001). The goal of the 2000 sampling was to test sampling protocols and determine the funding level and crew structure needed to implement the monitoring plan. A pilot project was conducted in 2001 in 16 watersheds to refine sampling protocols and to answer other questions related to implementing the monitoring plan (Gallo et al. 2002). Full implementation of the monitoring plan began in 2002, although the number of sampled watersheds sampled was limited to 24 because of funding (Gallo et al. 2003). We continued sampling watersheds in 2003, completing 30, again under a limited budget. The purpose of this report is to provide an overview of monitoring efforts in 2003.

Program Monitoring Objectives

The objectives of the 2003 program included:

- Standardize and streamline AREMP protocols by: 1) have AREMP and the PacFish/InFish program – also known as PIBO – use common protocols for a set of core attributes. 2) Examine attributes to determine the effect of different calculation methods. 3) Recommend changes in AREMP sample design to be able to best determine status and trend of watershed condition, when operating under a reduced budget.

- Develop and refine a decision support model and indicator evaluation curves for each of the seven aquatic provinces in the NWFP area.
- Refine a data quality assurance/quality control program.
- Coordinate efforts to standardize watershed-monitoring efforts within the Pacific Northwest.

A complete discussion of each of these objectives is provided in subsequent sections. Included for each topic are a brief introduction, methods, and the results. In addition, a Lessons Learned section discusses a change in crew structure. A Budget Update section provides refined estimates of the budget and personnel required to accomplish the tasks assigned to the module.

2003 WATERSHED SAMPLING

Thirty watersheds spread throughout the Plan area were sampled during 2003 (Figure 1). These watersheds were sequentially sampled from the subset of the two hundred fifty watersheds originally selected for monitoring the Northwest Forest Plan. The 250 watersheds were selected at random using generalized random stratified tessellation survey design, which guarantees a spatially balanced sample. Watersheds must contain a minimum of 25 % federal ownership (USDA Forest Service, USDI Bureau of Land Management [BLM], or USDI National Park Service) along the total length of the stream (1:100,000 National Hydrography Dataset stream layer) to be considered for sampling in the monitoring plan.

Different Types of Field Sampling

Throughout the sections titled Field Efforts, Quality Assurance Program, and parts of the Special Projects there are references to different types of surveys. Each type of survey, generally, refers to a different point in time and a different purpose for the data collected. The survey types (with definitions) are as follows:

1. Initial Surveys – These surveys were conducted at sites that had not been surveyed by the AREMP program at any prior point in time. The sites were surveyed within watersheds taken from the sequential list of 250 randomly chosen watersheds being used to assess the success of the Northwest Forest Plan.
2. QAQC Surveys (also known as, "blind-checks") – These surveys were conducted at one randomly selected site per watershed (in prior years – 2001 and 2002 – there were two randomly selected sites per watershed). The intent of these surveys was to check the ability of crews to measure the same segment of stream consistently. These surveys always took place after the Initial Survey and were done by a different randomly selected crew than who conducted the Initial Survey.
3. Trend Surveys – These surveys were conducted during the 2003 field season at sites that had both an Initial Survey and a QAQC Survey during the 2002 field season. These sites were surveyed by different field crews at all three surveys (there was only one QAQC Survey crew during the 2002 field season). The intent of these sites is to assess trend in a subset of the 250 watersheds prior to completion of the full cycle of sampling.

Of the 250 watersheds, 30 were sampled for Initial Survey sites during the 2003 field season (Table 1). To allow for temporal differences in stream flow across the Plan area and to minimize the impact of a drought occurring throughout the Pacific Northwest, crews sampled all watersheds in California, then Oregon, and finished the field season in Washington. Within each state, randomly assigned crews sampled watersheds. Twenty-eight QAQC surveys and 11 trend surveys were also completed.

Within each watershed, sample sites were randomly selected using the same procedure used to select watersheds. Crews sampled as many Initial Survey sites as possible during the sample period, 5.5 on average. A single crew conducted all sampling within individual watersheds. Crews collected a variety of data on the physical, biological, and chemical characteristics of streams (Table 2). A synopsis of the data collection methods is available online at: http://www.reo.gov/monitoring/watershed.

STANDARDIZING PROTOCOLS

Whitacre (2004) conducted a protocol comparison test in 2002 that compared AREMP and PIBO (and other state and federal agency) protocols for common attributes and suggested that both efforts could "learn from each other," in an effort to increase the precision of sampling measurements. As a result, we began efforts to standardize protocols between our two programs. Our emphasis in 2003 was to standardize site layout, pool definition, and how to measure gradient.

We also examined differences in calculation methods and used these results to suggest modifications to our survey methods. A summary of our conclusions follows; more detailed documentation of these analyses will be available at http://www.reo.gov/monitoring/reports.htm - watershed.

Site Layout

The major change to site layout involved using banded site lengths as opposed to (20 * Bankfull Width). Once the average bankfull width was determined at the beginning of the site (there was no change to this part of the protocol), the site length was then determined according to the following:

- Bankfull Width < 8 m then site length = 160 m
- Bankfull Width > 8 m & < 10 m then site Length = 200 m
- Bankfull Width > 10 m & < 12 m then site Length = 240 m

The above pattern of determining site length continued up to a maximum site length of 480 m. We also attempted to start and end all sites on a pool tail crest (this was done for determining gradient, see below). Crews made every effort to start the site on the pool tail crest and were given the flexibility to move the beginning of the site downstream 10 m or upstream 50 m in order to locate a pool tail crest (see definition of pool below). Likewise ending the site had the same constraints (this could lead to a 530 m maximum site length). If a pool tail crest was not located within the 60 m of stream (10 m downstream, 50 m upstream) at the beginning, end, or both, then the site started or terminated as originally measured.

The biological samples collected at each site dictate that the stream channel remain as undisturbed as possible prior to the initiation of collection activities. This proved difficult to accomplish for most field crews because the fish and aquatic amphibian, periphyton, and terrestrial amphibian sampling all take place in proximity to the transects within the reach. Because of this fact, the site layout had to take place before the sample collection could begin. Crews made every effort not to impact the channel during site layout.

Site Relocation

An examination of the Global Positioning System (GPS) coordinates collected during initial, QAQC, and trend surveys was conducted to determine how close crews get to the same point, i.e., is the GPS coordinate reliable enough to monument sites? Overall (Table 6), 80 % of the sets of coordinates (regardless of pairing; n=58) were within the nominal accuracy of the GPS units (±30 m) and approximately 40 % of the sites were within the “good” range (± 10 m). (Note that three sites were dropped from the analyses because of the distance between the coordinate at time one and time two was more than the normal margin of error and probably a data recording issue or incorrect datum on the GPS unit.)

The dataset was then divided into four subsets which addressed the following time one and time two pairs: 2002 Initial Survey and 2002 QAQC Survey (n=5); 2003 Initial Survey and 2003 QAQC Survey (n=26); the Trend Survey sites (2002 Initial Survey and 2003 Trend Survey; n=18); and the set of sites surveyed at Glade Creek in 2000 and again in 2002 (n=10). For the first three combinations, between 80 % and 90 % of the sites were within the nominal range of the GPS units (Table 6). The Glade Creek set of coordinates were considerably farther off, only 30 % of the sites were within the nominal range and the balance was within 100 m between the time one survey and the time two survey (Table 6). These results suggest that using only GPS coordinates is not sufficient for accurately monumenting the beginning of each site if we want to be within ± 10 m for any repeat surveys.

Pool Definition

An attempt was made to merge the AREMP definition of pool with the PIBO pool definition. We made an attempt to track both those pools that met the 2002 AREMP pool definition and those that met the new 2003 AREMP pool definition. Initially the only predicted difference was the inclusion of pools that “span at least 50% of the wetted channel width at the widest point” (the 2002 AREMP definition required that pools span the entire wetted width) and an internal mechanism tracked these two different types of pools. However, upon implementation of the new combined definition crews quickly discovered that there were considerable differences between the two definitions and the tracking mechanism failed to capture the pools the met each definition.

Pool Classification: a comparison of two methods

We compared pool data collected two different ways: 1) based on a using a longitudinal profile, 2) based on field crews classifying pools based on specific criteria according to field protocol definition. The longitudinal profile of the thalweg was measured by field crews along bed load of each site on increments that are approximately 1/100th of the site length apart. In addition to the normal increment points, points were also measured at the pool tail crest, pool maximum depth and the pool head. An algorithm was developed that a) classified every pool (depression) in the bottom of the channel regardless of depth, and b) rated pools according to the ODFW Habitat Benchmarks for pool quality (Moore 1997), which ranks quality by residual pool depth at given channel width – gradient combinations. The pools were then split into two categories: a) quality pools – those that met at least the minimum pool criteria (from Moore 1997), and b) desirable pools – those that met or exceeded the highest quality benchmark for pools (Moore 1997). These results were compared to what the field crews classified according to the protocol definition of pools.

Quality pools were significantly different between the longitudinal results and the pool classification results, with the computer typically classifying more quality pools (p=0.0001). Desirable pools between the two methods were not significantly different (p=0.53), however, the computer typically classified more desirable pools. Consistency was addressed through the slope of time one and time two type plots (in theory the slope should be one indicating that the same value was found in both surveys). Field crews were slightly more consistent in classifying pools than the computer using the longitudinal profile. In general the computer was consistent between times one and two one out of three years for both desirable and quality pools, while crews were consistent, on average, approximately every other year for both desirable and quality pools. Based on these results we concluded that surveying the longitudinal profile for “post-classification” of pool habitat did not perform better than field crews and therefore we dropped surveys of the longitudinal profiles.

Gradient

Gradient is the ratio of the change in elevation to length from the start point to the end of the survey site. Generally, this translates into change in elevation over the length of the site. The change in elevation was calculated as the change in both the bed surface and the water surface between the beginning and end of the survey site. The distance between the beginning and end of the survey was calculated using four different methods.

1. The *stream* length is the actual length of channel measured along the site thalweg by the field crew with a tape measure;
2. The *straight line* is the straight distance between the thalweg point at the first and last transect of the reach;
3. The *transect* length is the sum of the straight line distances between the thalweg point at each transect; and
4. the *thalweg* length is the sum of the distances between the longitudinal points – taken along the thalweg – spaced approximately every 1/100th of the site length.

There was no significant difference between the gradients calculated with each of the different site lengths. Further, decomposition of the gradient ratio revealed that there were no significant differences between the different lengths or between the different elevation calculations.

Additional measurements were collected in the field in an attempt to get a more precise measurement of elevation change, i.e., averaging multiple measurements instead of relying on just one measurement. Water surface on the left edge at the first and last transect was used for gradient. As a function of the way crews collect channel morphology data, an initial set of measurements was always collected. AREMP adopted the PIBO practice of resurveying the change in reach elevation at least a second time and sometimes a third time. If the change in elevation across the reach did not agree within 10 % between the initial measurement and the second measurement then a third measurement was taken and the three measurements were averaged together.

Examination of the repeatability of the change in elevation measurement within a crew revealed interesting results. Of the six field crews in place during the 2003 field season, three crews had very little problem determining a gradient that was within 10% of the original gradient value. The remaining three crews had almost the opposite results in that they were rarely able to obtain a gradient within 10% of the original value, even with two additional attempts. There are two possible explanations. First, the latter crews, by chance, surveyed most of the low gradient watersheds which makes the 10% value a much smaller target. Second, there could be problems with equipment that were not realized at the time of the survey. A test of the field equipment will be conducted during the spring of 2004. In general, the conclusion from the gradient analysis is that it does not seem to matter which length and which change in elevation is used to calculate gradient.

Substrate

AREMP field crews collect information on both the Pool Tail Crest (PTC) Fines and particle size (used to calculate D_{50}). We explored the relationship between PTC and D_{16} to see if the latter might provide a good estimate of PTC, and allow us to save field time by not collecting PTC. However we found it impossible to relate the two values at a given site in a meaningful manner, possibly because of the difference in scales between the two indicators, i.e., PTC Fines are 0-100% and D_{16} ranges from 1 mm to 4096 mm. Attempts were made to transform the data using different techniques, however, this only changed the scaling of the axes on the graphs and did not change the relationship (or lack thereof). We therefore concluded that field crews would continue to measure both particles and Pool Tail Crest Fines as per previous years.

Sinuosity

Sinuosity is the ratio of the site length to the valley length (straight line) and is thus influenced by how the site length is calculated (see Gradient above for a description of the different site lengths and how they are calculated). This analysis turned into a two-part exercise. First, an extensive sweep of the data revealed several errors which impacted one or more of the lengths associated with several sites. For example, one crew would consistently space the transect farther apart than the actual increment value which, for example, led to a Site Length of 150 m when in fact the actual Site Length was 165 m (and thus a Sinuosity <1). Another problem was large obstructions in the channel, such as culverts or extensive logjams, and how the crew measured the channel length (either accounting for or not accounting for the obstruction). The handling of obstructions will be clarified in the 2004 field protocol. Second, the actual calculation of sinuosity given the different site lengths revealed the sinuosity calculated using the sum of transect lengths divided by a straight line length (calculated using a laser level) was most repeatable between surveys.

SAMPLE DESIGN

Monitoring requires two different types of information in order to be successful; both status and trend of the resource in question. Status and trend have very different requirements for the sample design. Ideally, status is measured with the sample spread over the largest portion of the resource possible — given monetary and logistical constraints. Whereas the best assessment of trend is accomplished by directing the repeat measurement of sample units through time.

The base sample design for AREMP is to revisit watersheds every fifth year in a cyclic pattern. Each year, as new data are gathered, the assessment of status will become more robust. After a watershed is measured twice, some indication of trend, for that watershed, can be assessed. The problem with this design is the length of time that must elapse before an adequate assessment of trend is available (ten years for all 250 watersheds). Alternative approaches to the sample design were considered, an option chosen, and implementation took place during the

2003 field season. Discussions about the merits of each design took place with Tony Olsen and Phil Larsen (EPA – Corvallis).

Approach 1: Five year rotation

The sample design for AREMP is structured to generate both status and trend data, with the former taken from the yearly samples and the later collected as each watershed is revisited.

Advantages:

1. Because the sample design is already structured this way, there is no need to measure additional watersheds.
2. Logistics and coordination of field crews is essentially "base-line".

Disadvantages:

1. A full ten years will have to elapse before we can assess trend of watersheds across the NFP.
2. If the sample of 250 watersheds is redrawn for various reasons, e.g., state-federal coordination efforts (see above) then there would be little to no trend information associated with the watersheds AREMP has already sampled.

Approach 2: Resurvey complete watersheds from prior year (2002)

This approach targets a certain percentage of the watersheds surveyed in 2002 for resurvey in 2003. Those selected watersheds are completely resurveyed, i.e., all sites in the selected watersheds surveyed in 2002 would be resurveyed in 2003.

Advantages:

1. We would only have to coordinate resurveys in a small number of watersheds (field logistics would be easier).
2. Trend data is readily available after the second year field season (unlike Option 1 where this information would not be available until year 6).

Disadvantages:

1. The survey sample of watersheds across years is relatively small compared to the total sample size.
2. The number of sites resurveyed between years might be artificially small if the number of sites surveyed in 2002 is small.

Approach 3: Resurvey two sites in several watersheds

The quartuple method involves selecting a set of watersheds–in the same fashion as the previous option–and then surveying those sites twice that were selected for Quality Assessment (QA) visits (see above) in 2002 again in 2003. This gives us four visits to the same site in two years by four different crews.

Advantages:

1. Trend data is readily available after the second year field season (unlike Option 1 where this information would not be available until year 6).
2. The resurvey work would become part of the QA resurvey program.
3. AREMP would end up with resurveys in more watersheds than Option 2.
4. AREMP would end up with approximately the same number of sites resurveyed as Option 2.
5. By spreading the sample out over a larger area, theoretically, trend detection will exhibit more stability in the estimates.

Disadvantages:

1. AREMP would have fewer resurveyed sites within each watershed.
2. There are additional travel expenses, logistics, and field coordination to move crews between watersheds.

Sample Design Results & Discussion

For the 2003 field season, AREMP adopted a modification of the “quartuple” approach. Rather than sample each site twice in 2003, only a single survey was conducted (for a total of three surveys conducted at the same site over two years). As a starting point, AREMP resurveyed 20 sites from 11 watersheds surveyed during the 2003 field season. These twenty sites were the same sites as those sampled for Quality Assessment during the 2002 field season. The watersheds randomly selected were taken from the sequential sample list of watersheds surveyed during the 2003 field season. The results of these Trend Surveys are not yet available.

DECISION SUPPORT MODELING EFFORT

AREMP will be using a decision support model to assess watershed condition. Decision support models are not mathematical or statistical models, nor are they used for prediction. These models simply document a decision process and can be used to apply the same decision process to evaluate watershed condition across time and space. These models evaluate individual watershed condition indicators then aggregate the variables in a transparent manner. Using a decision support model has numerous advantages because assessments are repeatable and they can be conducted at any spatial scale. More importantly, as our understanding of how watersheds function increases, the model can be refined and rerun on data from earlier time periods to correct deficiencies. Additional details on decision support models can be found on our website.

AREMP conducted a series of workshops during which expert teams from each physiographic province (Appendix C) convened to refine the decision support model for their province and conduct a rigorous peer review. A “straw man” model was constructed based on that proposed by Reeves et al. (2004). A set of generalized evaluation criteria were also developed. This model and criteria were given to workshop participants as a starting point for model refinement.

We began the workshop by looking at the model as a whole, then delving into each indicator class (e.g., roads). For each class, we described the processes that should be accounted for in the model, then selected the indicators that were the best surrogates for each process. For example, in the roads evaluation, indicators were selected to describe the hydrologic connectivity of the road with the stream, the potential for mass failure, and floodplain constriction. As we discussed each indicator, we developed evaluation criteria and determined how the indicator evaluation scores should be aggregated. In the end, we revisited the model structure as a whole and weighted individual indicators.

Although indicators included in the decision support model were specified by Reeves et al. (2004), workshop participants determined how the indicators were used in the model. For example, an evaluation of riparian vegetation was included in each of the provincial models.

However, the width of the riparian buffer varies across provinces, as does the type of vegetation that is evaluated. Consequently, the evaluation of individual indicators, particularly roads and vegetation vary considerably across provinces.

The purpose of using the decision support model is to provide a consistent assessment of watershed condition across the Forest Plan area. While constructing the model, numerous decisions were made (e.g., evaluation curve values and indicator weights) that were based on data, published literature, and professional judgment. As part of the quality assessment of the model and its results, we documented the basis for each decision as well as each workshop participant's confidence in the decision. If the model produces nonsensical or questionable results, we can revisit the relevant decision points as a method of detecting problems.

In all, 72 people representing seven federal and state agencies participated in the workshops (Appendix C). To date, all models have been constructed and we are in the process of going over the results with workshop participants to refine the models. When model refinement and validation is complete, models and evaluation criteria will be given to local agencies for their use. The models will also be published in a forthcoming general technical report.

LANDSLIDE ANALYSES

Although Reeves et al. (2004) include landslides as an indicator that should be included in the monitoring program's assessment of watershed condition; a landslide component has yet to be implemented. The monitoring program made progress on developing a landslide assessment this year by conducting a workshop in which participants began developing an assessment protocol that will be implemented by the monitoring program. Eight geologists, geomorphologists, and hydrologists from federal agencies and the private sector were involved in the workshops (Appendix B). The assessment builds on other landslide assessment activities currently being conducted in the Pacific Northwest.

The proposed assessment uses landslide information to calibrate a GIS model that identifies areas within watersheds that have high potential for mass wasting. Existing landslide data will be used when possible, and gaps will be filled using aerial photograph interpretation and field verification. The model uses information such as slope, hillform shape, and geology to identify areas with high landslide risk. Dan Miller of Earth Systems Institute constructed the model for the Coastal Landscape Analysis and Modeling Study.

In the decision support model, indicators such as density of roads and harvest in high hazard areas will be evaluated. Three of the seven provincial decision support models contain evaluations of road density in hazard area evaluations. Roads-related evaluations will be incorporated into the remaining models in the next two years, as will harvest evaluations.

QUALITY ASSURANCE PROGRAM

Introduction

The Quality Assurance (QA) program within the AREMP program consists of several major components. Those components are generally either field related or non-field related. Field related components of the QA program include training crews, monitoring crew data collection methods, and conducting "blind-checks" (from the Quality System Management Plan [QSMP], Palmer 2002). Non-field related components include scrutinizing field data for errors, conducting exit surveys of crews, and tracking internal AREMP information. In addition to the annual reporting of the QA cold-check information, we have included two additional sections that represent considerable efforts made by the AREMP team during the last year. First, members of the AREMP team made progress toward documenting how the AREMP program was meeting the various components of the QSMP. Second, as efforts were underway in other areas of the program to standardize with other large scale monitoring programs and proposed national level field protocols (see above), an internal document that addresses calculation of indicators was drafted. Finally, there is a brief discussion of field audits and potential future direction for that part of the QA program.

AREMP QSMP Documentation

The goal of the QSMP is to ensure that all data collected are scientifically sound and of known quality. AREMP was selected as the pilot program for implementing the QSMP across all of the Northwest Forest Plan monitoring programs. Efforts were made to document how AREMP is meeting each section of the QSMP. For example, under the heading of "TRAINING AND

CERTIFICATION" (Palmer 2002, section 11.2) lesson plans for each indicator (individual section of the field protocol that address one stream channel indicator measured in the field, such as Percent Pool Tail Crest Fines) were documented with information such as (Palmer 2002, Table 5) the Course Objective, Lesson Outline, Preparation Activities, and Lesson Plan. Another example is the "CALIBRATION AND MAINTENANCE OF EQUIPMENT" (Palmer 2002, section 11.5) where efforts were made to document the procedure for electronic equipment calibration (for each different type of equipment), the frequency of calibration, and the results of calibration efforts. While considerable progress was made documenting sections of the AREMP program with respect to the QSMP, this work will continue with the goal of completion by the end of the 2004 calendar year.

Calculations Document

As a function of having standard operating procedures for the various components of AREMP coupled with the efforts to standardize field protocols with PIBO (see above) a document was written (still in draft form) that outlines the details of calculating the indicator values from atomic level data. Included are the steps involved to make the calculations as well as the equation(s). The equations used are taken from peer-reviewed literature or commonly used references on the particular subject matter. These equations typically involve the calculation of the indicator value. For example, when a site is surveyed, under normal conditions, 10 different rock particles are measured at each of 11 transects for a total of 121 particles. These individual measurements are the atomic level data that are used to calculate the D_{50} (indicator) value for the reach. Where there are additional steps that apply specifically to the AREMP dataset they are outlined when appropriate. This document is close to being finalized and work will continue with the goal of completion during the spring of the 2004 calendar year.

Remeasurements (blind-checks) - Methods

The blind check (QAQC Survey) component of the field effort was conducted in a similar manner as that of the 2001 field season (AREMP reinstated the rotating randomly selected crew to conduct the second survey) with one exception. The second survey crew was only given the initial transect flag location and they had to conduct a full survey from that start point including the site length. The second crew did not resurvey any watershed in which they conducted the original sampling. During the resample, data were collected for the same suite of indicators (Table 2) using the same collection methods as the original intensive survey. Each watershed was resampled within two - four weeks after the original sample.

Comparisons were made between the initial survey and the second survey using regression analysis. If the two crews measured the same indicator at the same location, they should generate the same value for the indicator. Consequently, if the results from crew 1 were graphed as a function of crew 2's results, the data points should fall on the 1:1 line. Regression lines were fit to the 2003 data. Tests were then conducted to determine if the slope of the regression line was significantly different than one (H_o:β=1, H_a:$\beta \neq$1, α=0.05), which would suggest that one set of values was substantially different than the second. Simple linear correlations were also generated. These graphs (for 2001, 2002, & 2003) can be viewed in the Power Point presentation titled QAQC_Time1_Time2.ppt at the following website: http://www.reo.gov/monitoring/reports.htm - watershed.

Variance decomposition (or partitioning) for the different indicators (Table 4) was conducted using the following model:

$$Attribute = Creek + Site(Creek) + Visit(Site) + \varepsilon$$

where *Creek* represents the variance between watersheds, *Site(Creek)* is variance associated with sites within each creek, and *Visit(Site)* is the variance associated with the difference between visits. The last term (ε) is the residual error term, which includes all variance not accounted for by the other terms, including the difference in the environment between sample time one and time two. These graphs can be viewed in the Power Point presentation titled QAQC_Variance_Decomposition.ppt at the following website: http://www.reo.gov/monitoring/reports.htm - watershed.

Remeasurement (blind-check) - Results and Discussion

During the 2003 field season, 28 sites in 30 watersheds (17% of the total sites surveyed) were resurveyed. Plots of the initial survey and the secondary survey revealed several interesting points (Table 3):

1. Typically, the relationship between the two surveys – as indicated by the simple linear correlation coefficient – was stronger in the habitat indicators (such as number of wood pieces, number of pools, average residual pool depth) and water chemistry indicators in 2003 than in 2002. Channel morphology, on the other hand demonstrated a weaker relationship across all indicators in 2003 than 2002.
2. Of the 17 indicators, 16 had a slope of less than one (reject Ho:β=1 in favor of Ha:$\beta \neq 1$; indicating that the indicator values for the QAQC Surveys were less than those of the Initial Survey) – only Conductivity had a slope greater than one.
3. Of those slopes, only three were not considered significantly different from one (Gradient Sinuosity, and D_{50}).

The variance decomposition results also revealed interesting information:

1. The residual (or unexplained) error and the between crew variance (these two terms together are also referred to as the "noise") decreased considerably from 2002 to 2003 for eight of the 17 indicators. An additional six indicators remained at approximately the same levels of noise between 2003 and 2002.
2. Overall, model fits – as judged by the Root Mean Square Error (Table 3) -– were better in 2003 than in 2002. Only three of the 17 indicators showed a decrease in model fit in 2003 and an additional two stayed at approximately the same levels as 2002. All of the remaining indicators improved in model fit.
3. Of the 17 indicators only three had an increase in overall variation (between watersheds, between sites, between visits, and error combined). Four held at approximately the same values of total variation as 2002, while the remainder decreased in overall variation.

In conclusion, while the QAQC Surveys tend to find smaller streams with fewer physical parameters, i.e., narrower, shallower, fewer pieces of wood, the total variation is more attributable to the differences in the environment, i.e., between watersheds and sites within watersheds, then it is to the differences between crews or unexplained error. This indicates a general improvement in the ability to measure almost all indicators. However, efforts will continue to be made to bring the two measurements (the Initial Survey and the QAQC Survey) into line with one another.

Field Audits

Field Audits were used by the Field Coordinators (AREMP field staff that oversee the field crews) to check on the status of field crews during mid-season. The audits are designed to capture information such as crews following safety guidelines and correct implementation of the field protocols. The field coordinators reported difficulty in using the Field Audits for a couple reasons. First, the form itself was outdated and needs an overhaul to be relevant to the current field protocols and crew structure. Second and more importantly, was the feeling of “spying” on the field crews. The role of the Field Coordinators is to provide guidance and direction to the field crews, however, the Field Audits did not allow for mid-course corrections of mis-implemented protocols (which would also lead to introduction of unknown bias(es) into the dataset). Because of this, AREMP personnel will redesign this part of the QA program in an attempt to build a mechanism that generates useful feedback for field personnel and the QA program.

PACIFIC NORTHWEST AQUATIC MONITORING PARTNERSHIP

The AREMP team leader again led the 2003 cooperative monitoring efforts between state, federal, and tribal agencies within Washington, Oregon, California, and Idaho - now known as the Pacific Northwest Aquatic Monitoring Partnership (PNAMP; Table 8). The following is a summary of progress made during 2003.

Relationship Building

1. Continued building relationships among numerous state and federal agencies involved with monitoring watershed condition in the Pacific Northwest. Several Indian tribes and Indian nations joined the Partnership.
2. Shared information about programs and identified areas of potential cooperation.
3. Created four additional workgroups: steering committee, fish population monitoring, effectiveness monitoring, and data management to meet Partnership member needs for better coordination in these areas.

Products[1]

A planning document titled "Recommendations for Coordinating State, Federal, and Tribal Watershed and Salmon Monitoring Programs in the Pacific Northwest" was produced (PNAMP 2004). This document includes background information on the coordination effort and chapters for:

1. Coordination structure planning module,
2. Watershed condition monitoring planning module,
3. Fish population monitoring module,
4. Effectiveness monitoring module,
5. Data management module.

A PowerPoint presentation describing how the partnership was formed, the benefits of a partnership, proposed products, and a request for permission to continue the partnership. This presentation was given to several "executive" policy groups, including the Regional Interagency Committee, Federal Caucus, Northwest Power Planning and Conservation Commission, Oregon Watershed Enhancement Board, Columbia River Inter-Tribal Fish Commission. The overwhelming response was to continue the partnership efforts, along with an invitation to return with a funding proposal.

Future PNAMP Efforts

The watershed condition workgroup (team leader is also the AREMP team leader) identified three focus areas for 2004:

1. Develop a common randomized sampling protocol that allows the greatest inference across the landscape.
    a. General agreement was reached that using a Generalized Random Tesselation Sampling strategy is the best way to ensure uniform, randomly distributed sample sites.
2. Identify a core set of indicators and associated protocols.

[1] All Of these products are available for distribution. Contact the authors for more information.

a. AREMP and US Forest Service – Washington Office personnel hosted a workshop where a field protocol test was developed. Funding is being requested so the test can be conducted during the 2004 field season.

3. Identify and develop GIS layers for use by Partnership agencies.

A funding proposal was developed that will allow hiring a full time coordinator, and also identifies the amount of in-kind services that agencies are expected to contribute. This will be presented to agency executives in spring, 2004.

The Columbia River Biological Opinion is now promoting PNAMP as a mechanism they will use to meet state, federal, and tribal coordination mandates.

LESSONS LEARNED

Staffing Changes

We returned to using a single five-person crew to sample each watershed in 2003, with individuals assigned to either the habitat or biological component of the survey. We also added field coordinator positions to assist in crew supervision in the field and general crew management tasks. Those tasks included checking the data for quality assurance, serving as the conduit for equipment repair and replacement, and serving as another check to ensure protocols are correctly followed. The field coordinator positions proved to be invaluable for ensuring a well coordinated field effort, although we found they often became stretched to thin because of all their duties. We also hired a two-person crew who was focused on site reconnaissance throughout the summer. Scouting watersheds involved, but was not limited to, tasks such as finding major access roads, camp sites, creek access points, determining which sample sites are suitable for survey, and placement of water temperature probes.

BUDGET UPDATE

The Bureau of Land Management State Director asked AREMP to hire Student Conservation Association (SCA) interns for the 2004 field season. Therefore, the anticipated costs for watershed surveys in 2004 (Table 5) assumes that AREMP is able to include SCA volunteers as part of our existing field crew structure. This will help offset increased program costs associated with the necessity to rent commercial vehicles (instead of leasing less expensive US Forest Service vehicles). For full implementation of the monitoring plan, i.e., sample 50 watersheds, it will cost $26,184 to sample each watershed and $4,364 per sample site. This assumes that an average of 6 sites continues to be sampled in each watershed. These figures were derived from taking our total budget and dividing by the number of watersheds sampled, therefore the figures include overhead and other non-field related costs.

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Thanks to Bureau of Land Management (BLM) Rogue River Rangers who provided raft support, the BLM Buglab is conducting the laboratory analysis of the benthic macroinvertebrate samples. Loren Bahls, Ph.D. is completing periphyton sample analysis. The Cooperative Chemical Analysis Laboratory at Oregon State University in Corvallis, OR conducted laboratory analysis for water chemistry.

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TABLES

Table 1. Watersheds sampled in 2003 by the Aquatic and Riparian Effectiveness Monitoring Program (AREMP). Included is the state, county, physiographic province, the National Forest (NF), National Park (NP), or Bureau of Land Management (BLM) District that manages the watershed, the watershed name, and the major river system in which the watershed is located.

State	County	Province	Administrative Unit	Creek Name	Major River System
CA	SISKIYOU	KLAMATH/SISKIYOU	KLAMATH NF	SOUTH FORK SALMON RIVER[2]	SALMON RIVER
CA	SISKIYOU	KLAMATH/SISKIYOU	KLAMATH NF	CRAWFORD CREEK	SALMON RIVER
CA	SISKIYOU	KLAMATH/SISKIYOU	KLAMATH NF	TENMILE CREEK	LOWER KLAMATH RIVER
CA	SISKIYOU	KLAMATH/SISKIYOU	KLAMATH NF	PAYNES LAKE CREEK	SCOTT RIVER
CA	GLENN	KLAMATH/SISKIYOU	MENDOCINO NF	UPPER BLACK BUTTE RIVER[1]	MIDDLE FORK of the EEL RIVER
CA	TRINITY	KLAMATH/SISKIYOU	SHASTA/TRINITY NF	PHILPOT CREEK	SOUTH FORK of the TRINITY RIVER
CA	DEL NORTE	KLAMATH/SISKIYOU	SIX RIVERS NF	SHELLY CREEK	SMITH RIVER
OR	COOS	COAST RANGE	COOS BAY – BLM	BREWSTER CANYON	COQUILLE RIVER
OR	COOS	COAST RANGE	COOS BAY – BLM	UPPER CAMP CREEK	UMPQUA RIVER
OR	KLAMATH	HIGH CASCADES	CRATER LAKE – NP	EAST FORK ANNIE CREEK[1]	UPPER KLAMATH LAKE
OR	KLAMATH	HIGH CASCADES	DESCHUTES NF	SUMMIT CREEK	DESCHUTES RIVER
OR	JEFFERSON	HIGH CASCADES	DESCHUTES NF	CANYON CREEK	DESCHUTES RIVER
OR	JOSEPHINE	KLAMATH/SISKIYOU	MEDFORD – BLM	ROGUE RIVER/BIG WINDY CREEK	ROGUE RIVER
OR	COOS	KLAMATH/SISKIYOU	MEDFORD – BLM	UPPER WEST FORK COW CREEK	UMPQUA RIVER
OR	JACKSON	KLAMATH/SISKIYOU	MEDFORD – BLM	WEST FORK TRAIL CREEK	ROGUE RIVER
OR	DOUGLAS	KLAMATH/SISKIYOU	MEDFORD – BLM	WEST FORK COW CREEK/BEAR CREEK	UMPQUA RIVER
OR	CLACKAMAS	WEST CASCADES	MT HOOD NF	CEDAR CREEK	SANDY RIVER
OR	CLACKAMAS	WEST CASCADES	MT HOOD NF	DRAW CREEK	SANDY RIVER
OR	WASCO/HOOD RIVER	HIGH CASCADES	MT HOOD NF	HEADWATERS FIFTEENMILE CREEK	HOOD RIVER
OR	JACKSON	KLAMATH/SISKIYOU	ROGUE RIVER NF	ASHLAND CREEK	ROGUE RIVER
OR	CLACKAMAS	WEST CASCADES	SALEM – BLM	UPPER MOLALLA RIVER[1]	MOLALLA RIVER
OR	COOS/CURRY	COAST RANGE	SISKIYOU NF	HEADWATERS SOUTH FORK COQUILLE RIVER[1]	COQUILLE RIVER

[2] All sites originally surveyed in 2002 and one site was surveyed again in 2003 as a Trend Site (see text for further details).

State	County	Province	Administrative Unit	Creek Name	Major River System
OR	JOSEPHINE	KLAMATH/SISKIYOU	SISKIYOU NF	LOWER EAST FORK ILLINOIS RIVER	ILLINOIS RIVER
OR	JOSEPHINE	KLAMATH/SISKIYOU	SISKIYOU NF	SIXMILE CREEK	ILLINOIS RIVER
OR	LANE	COAST RANGE	SIUSLAW NF	UPPER FIVE RIVERS	ALSEA RIVER
OR	DOUGLAS	WEST CASCADES	UMPQUA NF	LITTLE RIVER HEADWATERS	UMPQUA RIVER
OR	LANE	WEST CASCADES	WILLAMETTE NF	NORTH FK OF MIDDLE FK WILLAMETTE/FISHER CREEK	WILLAMETTE RIVER
OR	LANE	WEST CASCADES	WILLAMETTE NF	UPPER MIDDLE FK WILLAMETTE/ECHO CREEK	WILLAMETTE RIVER
OR	LANE	WEST CASCADES	WILLAMETTE NF	MIDDLE FORK WILLAMETTE/LARISON CREEK	WILLAMETTE RIVER
OR	LANE	WEST CASCADES	WILLAMETTE NF	QUARTZ CREEK	MCKENZIE RIVER
OR	KLAMATH	HIGH CASCADES	WINEMA NF	THREEMILE CREEK	UPPER KLAMATH RIVER
WA	SKAMANIA	WEST CASCADES	GIFFORD PINCHOT NF	ELK CREEK	LEWIS RIVER
WA	SKAMANIA	WEST CASCADES	GIFFORD PINCHOT NF	ALEC CREEK	LEWIS RIVER
WA	SKAMANIA	WEST CASCADES	GIFFORD PINCHOT NF	TWIN FALLS CREEK	LEWIS RIVER
WA	SKAMANIA	WEST CASCADES	GIFFORD PINCHOT NF	BIG LAVA BED FRONTAL CREEK[1]	LITTLE WHITE SALMON RIVER
WA	PIERCE	WEST CASCADES	MT BAKER/ SNOQUALMIE NF	UPPER WHITE RIVER - SILVER CREEK	PUYALLUP RIVER
WA	SNOHOMISH	NORTH CASCADES	MT BAKER/ SNOQUALMIE NF	LOWER WHITE CHUCK RIVER	SAUK RIVER
WA	PIERCE	WEST CASCADES	MT BAKER/ SNOQUALMIE NF	CLEARWATER RIVER	PUYALLUP RIVER
WA	CHELAN	NORTH CASCADES	NORTH CASCADES NP	BOULDER CREEK	LAKE CHELAN
WA	OKANOGAN	NORTH CASCADES	OKANOGAN NF	MAINSTEM LOWER METHOW RIVER\GOLD CREEK	METHOW RIVER
WA	JEFFERSON-MASON	OLYMPIC	OLYMPIC – NP/ OLYMPIC – NF	HAMMA HAMMA RIVER[1]	HAMMA HAMMA RIVER

Table 2. Summary of methods used to collect data on Aquatic and Riparian Effectiveness Monitoring Program (AREMP) watershed condition indicators.

Indicator	Collection	Method
Physical Habitat		
Bankfull Width	Field	Width between bankfull points on each transect
Bankfull Depth	Field	Average depth at the bankfull width on each transect
Bankfull Width: depth	Calc.	= bankfull width / mean bankfull depth
Gradient	Calc.	= rise / run of the sample reach
Sinuosity	Calc.	= stream length / valley length
Entrenchment ratio	Calc.	= flood prone width / bankfull width
Substrate D_{50}[3]	Field	Modified Wolman pebble count
Percent fines	Field	Klamath grid
Number of Wood Pieces	Field	Tally of wood in sample reach
Wood frequency	Calc	Tally of wood in sample reach/reach length
Number of Pools	Field	Tally of pools in sample reach
Pool frequency	Field	Tally of pools in sample reach/reach length
Pool residual depth	Calc.	= Pool max depth - pool tail crest depth
Water Chemistry		
Total Kjeldahl nitrogen[4]	Field	Water collected for lab determination
Total phosphorus[3]	Field	Water collected for lab determination
Dissolved oxygen	Field	YSI 556 MPS meter
Conductivity	Field	YSI 556 MPS meter
pH	Field	YSI 556 MPS meter
Temperature	Field	Onset Optic Stowaway data logger
Biological Sampling[5]		
Periphyton	Field	Removal from known substrate area
Macroinvertebrates	Field	Kicknet sampling in riffle habitats
Amphibians	Field	Electrofishing and timed stream bank searches
Fish	Field	Electrofishing

[3] Analyzed both with and without bedrock measurements because of the influence that a single point will have in a regression and the relative simplicity for crews to identify bedrock and generate the same answer.
[4] These data are not analyzed in the blind check (QAQC Surveys) because one sample is taken for the watershed.
[5] These data are not analyzed in the blind check (QAQC Survey) analysis because the data are not available for the macroinvertebrates and periphyton and because of the lack of a consistent metric for the fish and aquatic amphibians and the terrestrial amphibians.

Table 3. Aquatic and Riparian Effectiveness Monitoring Program (AREMP) correlation coefficients and slope test information for the initial survey and the second survey for the quality control blind checks during 2003. The correlation coefficient, slope of the fitted regression line and the probability of the test for Ho:β=1, are represented by r, β, and probability, respectively.

Indicator	2001 r	2002 r	2003 r	2001 β, Probability	2002 β, Probability	2003 β, Probability
Site Length	1.00	1.00	0.86	1.00, 0.81	1.00, 0.55	0.81, 0.09
Average Bankfull Width	0.99	0.97	0.86	1.19, 0.00	0.98, 0.66	0.63, 0.00
Average Bankfull Depth	0.76	0.62	0.07	0.86, 0.32	0.57, 0.00	0.05, 0.00
Average Bankfull Width:Depth Ratio	0.82	0.75	0.68	0.79, 0.05	0.65, 0.00	0.49, 0.00
Average Entrenchment Ratio	0.71	0.80	0.40	0.54, 0.00	0.76, 0.02	0.39, 0.01
Gradient	0.93	0.99	0.82	0.97, 0.63	0.98, 0.42	0.80, 0.07
Sinuosity	0.49	0.96	0.92	1.07, 0.84	0.92, 0.07	0.93, 0.4
D50	0.82	0.89	1.00	0.14, 0.00	0.67, 0.00	0.99, 0.78
% Pool Tail Crest Fines	0.60	0.47	0.40	1.07, 0.80	0.54, 0.03	0.31, 0.00
Wood Frequency	0.85	0.64	0.58	0.76, 0.01	0.44, 0.00	0.43, 0.00
Pieces of wood	0.81	0.59	0.67	0.66, 0.00	0.35, 0.00	0.67, 0.03
Pool Frequency	0.44	0.27	0.40	0.51, 0.02	0.15, 0.00	0.40, 0.00
Number of Pools	0.24	0.06	0.40	0.30, 0.01	0.04, 0.00	0.36, 0.00
Average Residual Pool Depth	0.74	0.30	0.33	0.91, 0.54	0.27, 0.00	0.15, 0.00
Dissolved Oxygen	-0.07	0.06	0.26	-0.05, 0.00	0.07, 0.00	0.23, 0.00
Conductivity	0.90	0.34	0.99	0.92, 0.32	1.07, 0.89	1.18, 0.00
pH	0.61	0.38	0.67	0.74, 0.16	0.53, 0.04	0.63, 0.02

Table 4. Aquatic and Riparian Effectiveness Monitoring Program (AREMP) variance decomposition by percent of the total variance for 17 indicators based on the paired Initial Survey and the QAQC Survey data for 2001, 2002, and 2003. RMSE stands for the Root Mean Square Error and gives an indication of how well the model fits the data (how much variation in the data is not explained by the model).

Indicator	Year	Percent variation for Watersheds	Percent variation for Sites within watersheds	Percent variation for Surveys within Site	Percent variation for Residual	Total Variation	RMSE
Average Bankfull Width	2001	49.68	0.01	2.95	47.36	62.64	5.61
Average Bankfull Depth	2001	59.31	5.82	0.00	34.87	0.04	0.12
Average Bankfull WD	2001	41.13	58.07	0.00	0.80	116.55	0.96
Average Entrenchment	2001	33.28	2.43	0.00	64.29	441.92	16.86
Gradient	2001	45.44	0.38	6.01	48.18	38.84	4.59
Sinuosity	2001	15.45	20.70	5.66	58.19	0.07	0.21
D50	2001	0.00	0.00	0.00	100.00	1486608.66	1219.26
D50 without BDRK	2001	13.81	4.96	2.83	78.40	18561.24	122.79
Pool Tail Fines	2001	53.31	22.11	24.45	0.13	468.68	10.73
Wood Pieces	2001	49.40	49.59	0.00	1.01	88.74	0.95
Wood Frequency	2001	52.28	0.84	1.78	45.11	0.00	0.04
Number Pools	2001	37.25	34.76	22.26	5.73	7.83	1.48
Pool Frequency	2001	49.38	3.12	18.78	28.73	0.00	0.01
Average Residual Pool Depth	2001	62.40	1.91	3.68	32.01	0.14	0.22
Dissolved Oxygen	2001	0.00	87.26	0.00	12.74	2.59	0.57
Conductivity	2001	40.37	59.61	0.00	0.01	4980.58	0.89
pH	2001	37.99	8.79	0.00	53.22	0.18	0.31
Average Bankfull Width	2002	58.91	32.50	6.43	2.15	27.34	1.53
Average Bankfull Depth	2002	31.98	28.58	0.35	39.09	0.03	0.10
Average Bankfull WD	2002	25.63	73.63	0.19	0.56	103.33	0.88
Average Entrenchment	2002	16.51	83.41	0.01	0.08	531.05	0.66
Gradient	2002	14.90	77.13	3.31	4.66	18.93	1.23
Sinuosity	2002	30.62	25.86	0.81	42.71	0.10	0.21
D50	2002	24.54	71.39	4.07	0.00	564061.47	151.59
D50 without BDRK	2002	0.37	99.47	0.16	0.00	69864.57	10.48
Pool Tail Fines	2002	44.05	0.23	0.00	55.72	157.88	9.38
Wood Pieces	2002	44.93	54.86	0.00	0.21	57.46	0.35
Wood Frequency	2002	50.03	16.71	0.00	33.26	0.00	0.02
Number Pools	2002	15.88	0.08	0.17	83.87	7.06	2.44

Indicator	Year	Percent variation for Watersheds	Percent variation for Sites within watersheds	Percent variation for Surveys within Site	Percent variation for Residual	Total Variation	RMSE
Pool Frequency	2002	24.07	29.04	0.81	46.08	0.00	0.01
Average Residual Pool Depth	2002	20.57	0.23	0.00	79.19	0.13	0.32
Dissolved Oxygen	2002	6.77	1.14	2.97	89.13	5.96	2.34
Conductivity	2002	18.86	7.65	2.63	70.85	10615.19	88.32
pH	2002	26.88	0.23	1.38	71.51	0.86	0.79
Average Bankfull Width	2003	83.03	15.87	0.00	1.10	24.36	0.52
Average Bankfull Depth	2003	12.88	40.53	3.09	43.50	0.02	0.10
Average Bankfull WD	2003	65.24	34.67	0.00	0.09	91.88	0.29
Average Entrenchment	2003	39.80	60.09	0.00	0.11	213.55	0.48
Gradient	2003	82.12	14.59	0.00	3.28	27.23	0.95
Sinuosity	2003	90.75	0.02	0.00	9.23	0.01	0.03
D50	2003	55.40	0.00	0.02	44.58	760717.98	582.46
D50 without BDRK	2003	57.14	42.85	0.00	0.01	6030.92	0.70
Pool Tail Fines	2003	42.49	0.25	1.31	55.95	32.33	4.30
Wood Pieces	2003	68.17	0.00	0.00	31.83	179.51	7.56
Wood Frequency	2003	56.68	4.25	0.00	39.08	0.00	0.03
Number Pools	2003	43.26	48.05	0.00	8.69	10.13	0.94
Pool Frequency	2003	41.43	11.39	11.79	35.39	0.00	0.01
Average Residual Pool Depth	2003	25.91	26.51	0.00	47.58	0.11	0.23
Dissolved Oxygen	2003	25.93	0.07	0.00	74.00	2.94	1.47
Conductivity	2003	97.56	0.01	1.17	1.26	6499.73	12.55
pH	2003	65.47	19.21	0.00	15.32	0.64	0.31

Table 5. Summary of the costs per watershed by three major categories of the Aquatic and Riparian Effectiveness Monitoring Program (AREMP). The Description column describes in general terms, the types of tasks that make up the area of operation. The next three columns give the cost per watershed for each of three scenarios, surveying 20, 250, and 50 watersheds, respectively. The cost per sample sites assumes an average of six sample sites in each watershed surveyed.

Categories	**Description**	**Cost per watershed @ 20 6th-field HUCS**	**Cost per watershed @ 25 6th-field HUCS**	**Cost per watershed @ 50 6th-field HUCs (full implementation)**
Program Coordination	Manage budget, purchases, and hiring personnel; communication and coordination with other agencies; presentations and reports.	$13,050	$10,067	$9,840
Watershed Sampling	Hiring, training, safety, travel, salaries for field crews; equipment purchasing, acquiring sampling permits, GIS support	$28,500	$26,367	$23,780
Decision Support Model	Refining evaluation curves and the decision support model structure; checking for errors, & archiving raw data; data analysis; and generating data summaries and preparing reports	$7,100	$4,900	$3,000
	Total Program Costs	$985,000	$1,136,858	$1,675,785
	Total/watershed	$44,782	$35,527	$26,184
	Total/sample site	$7463	$5,921	$4,364

Table 6. Breakdown of Global Position System coordinates collected at various combinations of time one and time two surveys. The Coordinate Pairing gives the description of which set of coordinates are used in each of the analyses (see text for more details), n is the number of paired coordinates used in the analyses, and the remaining columns indicate distances between the two coordinates. Percentages in parentheses are cumulative, i.e., they include all sites in prior distance categories.

Coordinate Pairing	n	Within 10 m	Within 30 m	Within 100 m	Greater than 100 m
All coordinate pairs	58	24 (41%)	22 (79%)	11 (98%)	1 (100%)
2002 Initial Survey & 2002 QAQC Survey	5	3 (60%)	1 (80%)	1 (100%)	0
2003 Initial Survey & 2003 QAQC Survey	26	11 (42%)	12 (88%)	2 (96%)	1 (100%)
2002 Initial Survey & 2003 Trend Site Survey	18	10 (56%)	6 (89%)	1 (94%)	1 (100%)
2000 Glade Creek Survey & 2002 Glade Creek Survey	10	1 (10%)	2 (30%)	7 (100%)	0

FIGURES

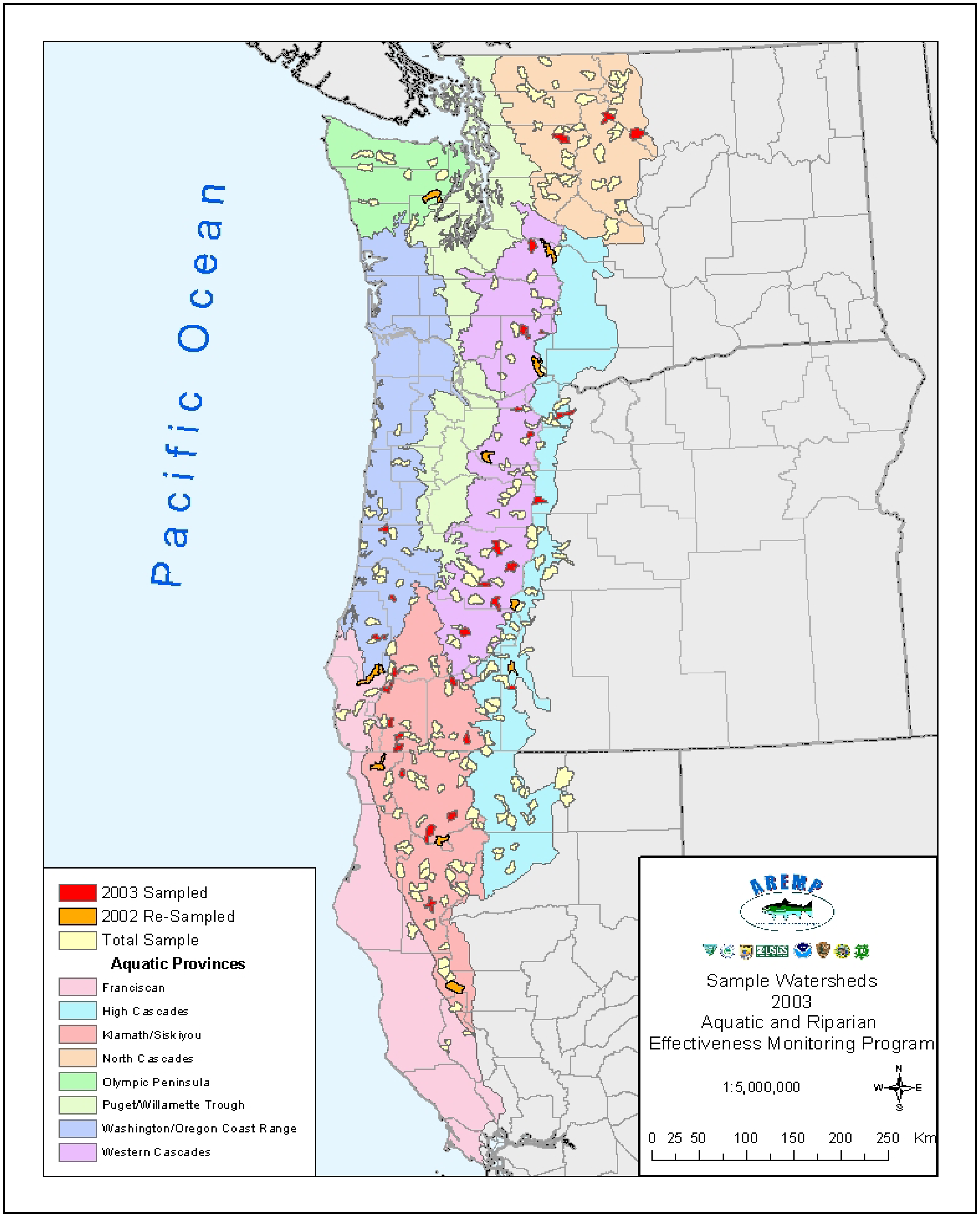

Figure 1. Map of the watersheds included in the Aquatic and Riparian Effectiveness Monitoring Program (AREMP) sampling. Watersheds sampled during the 2003 field season are highlighted in red. Resampled watersheds are highlighted in orange. The aquatic provinces of the Northwest Forest Plan are color coded in the background.

APPENDICES

Appendix A. A comparison of protocols used by two federal watershed monitoring programs: Aquatic-Riparian Effectiveness Monitoring Plan (AREMP) PIBO = the USDA Forest Service's monitoring for the Pacfish/Infish Biological Opinion.

Indicator	AREMP	PIBO
Reach Length	Reach length is 20x average bankfull width, with minimum and maximum lengths of 150 and 500 m, respectively.	Reach length is 20x average bankfull width with a minimum length of 80m.
Channel Cross Sections	Non-constrained reaches: Eleven evenly spaced transects. Constrained reaches: Six evenly-spaced cross-sections	Uses methods adapted from Harrelson et al. 1997. Four cross-sections are measured within each reach. A cross-section is located at the widest point within each of the first 4 riffles.
Longitudinal Profile	Profile measured using a laser range finder and an electronic compass following thalweg. Shots are taken on an increment that is approximately 1/100 of the reach length. Additional measurements are taken at pool tail crests, maximum pool depth, and pool head.	Stream length is measured along the thalweg.
Pool Frequency and Length	Pools defined as being longer than the average wetted width and habitat unit has to be channel spanning.	To be measured as a pool, must occupy greater than half the wetted width, be longer than wide, include the thalweg, and the maximum depth is at least 1.5 times the crest depth. Length measured along the thalweg between the head and tail crest.
Gradient	Stream gradient is calculated as the rise of the streambed divided by the length of the sampling segment. Gradient is the slope of the streambed, not the water surface.	Stream gradient is measured from the water surface at the downstream end of the reach to the water surface at the upstream end using surveyor's rod and transit level. Elevation change is measured twice, with the level at a different position each time. If the two measurements are not within 10 percent of each other then a third measurement is taken.
Sinuosity	Calculated using longitudinal	Calculated as the length of

Indicator	AREMP	PIBO
	profile data. Sum of the distances between profile points divided by straight-line reach length.	the stream channel along the thalweg divided by the straight line distance between the top and bottom of the sample reach.
Bankfull width: depth	Calculate BF width to depth ratios at every cross section. Eleven depth measurements are taken between and including the BF points at each transect for determination of mean bankfull depth.	Mean bankfull depth determined from 10 measurements of depth in the cross section, taken at equal distances. First measurement is randomly chosen.
Substrate	Percent surface fines in pool tail areas using USFS R5 SCI protocol. Grids are placed at 25%, 50%, and 75% of the distance along the pool-tail crest. Substrate particle size (D_{50}) determined by measuring 11 particles at systematic intervals within the 11 cross section transects.	Percent Surface Fines in Pool Tails: Using a modified version of USFS R5 SCI protocol. Grids are placed at 25%, 50%, and 75% of the distance along the pool-tail crest. 25 particles are sampled from each of the first 4 riffle/runs. Substrate Particle Size (D_{16}, D_{50}, and D_{84} in riffles/runs): uses Wolman (1954) method.

Appendix B. Landslide workshop participants.

Name	Affiliation
David Burns	Terrawave Systems
Courtney Cloyd	USDA Forest Service Region 6
Mike Furniss	Pacific Northwest Research Station
Ben Kozlowicz	Six Rivers National Forest
Dan Miller	Earth Systems Institute
Cindy Ricks Myers	Myers Consulting
Bill Shelmerdine	Olympic National Forest
Mark Smith	Six Rivers National Forest
Kirsten Gallo	AREMP
Steve Lanigan	AREMP

Appendix C. Decision support model workshop participants and contributors.

Name	Agency Affiliation	Position
Olympic Peninsula & Washington/Oregon Coast Range Province		
Workshop Participants		
Neil Armantrout	Eugene/Siuslaw BLM	Senior Aquatic Specialist
Bob Metzger	Olympic NF	Aquatic Program Manager
Paul Scheerer	Oregon Department of Fish and Wildlife	Acting Oregon Plan Monitoring Coordinator
Mike Furniss	Pacific Northwest Research Station	Hydrologist
Gordie Reeves	Pacific Northwest Research Station	Fish Research Biologist
Tom Mendenhall	Roseberg BLM	District Fish Biologist
Bob Ruediger	Salem BLM	District Fish Biologist
Karen Bennett	Siuslaw NF	Watershed Program Manager
Wade Sims	Willamette NF	ESA Consultation Fisheries Biologist
Additional Contributors		
Bill Shelmerdine	Olympic NF	Roads Engineer
Robin Stoddard	Olympic NF	Forest Hydrologist
Chip Clough	Roseberg BLM - Swiftwater area	Resource Specialist
Matt Fairchild	Roseberg BLM - South River	Resource Specialist
Cory Sipher	Roseberg BLM - South River	Resource Specialist
Cindy McCain	Siuslaw NF	Ecologist
North Cascades Province		
Workshop Participants		
Jim Doyle	Mt. Baker - Snoqualmie NF	Fish Program Manager
Gary Ketcheson	Mt. Baker - Snoqualmie NF	Watershed Program Manager
Reed Glesne	North Cascades NP	Aquatic Ecologist
Gordie Reeves	Pacific Northwest Research Station	Fish Research Biologist
Pierre Dawson	Wenatchee/Okanogan NF	SO Fisheries Biologist
Ken MacDonald	Wenatchee/Okanogan NF	Fish Program Manager
Tom Robison	Wenatchee/Okanogan NF	Watershed Program Manager
Additional Contributors		
Brady Green	MBS NF - Mt Baker RD	Fish Biologist
Greta Movassaghi	MBS NF - Mt Baker RD	Aquatic Biologist
Roger Nichols	MBS NF - Mt Baker RD	Geologist
Barry Gall	MBS NF - Skykomish RD	Aquatic Biologist
Ashley Rawhouser	North Cascades NP	Aquatic Ecologist
Pat Buller	North Cascades NP	Biologican Technician
Stan Zyskowski	North Cascades NP	Biologican Technician
Jackie Haskins	Wenatchee/Okanogan NF	Fish Biologist

Name	Agency Affiliation	Position
Richy Harrod	Wenatchee/Okanogan NF	Fire Ecologist
Terry Lillibridge	Wenatchee/Okanogan NF	Ecologist
Western and High Cascades Provinces		
Workshop Participants		
Mark Kreiter	Columbia River Gorge NSA	Hydrologist
Dan Rife	Deschutes NF	Forest Fish Biologist
Dan Shively	Mt Hood NF	Forest Fish Biologist
Dave Hohler	NRIS Tools	Branch Chief
Gordie Reeves	Pacific Northwest Research Station	Fish Research Biologist
Deborah Konnoff	Region 6	Aquatic Ecologist
Randy Frick	Rogue River - Siskiyou NF	Forest Fish Biologist
Jeff Dose	Umpqua NF	Forest Fish Biologist
Nikki Swanson	Willamette NF	Forest Fish Biologist
Wade Sims	Willamette NF	ESA Consultation Fisheries Biologist
Additional Contributors		
Nate Dachtler	Deschutes NF	Forest Fish Monitoring Lead
Brad Houslet	Deschutes NF	District Fish Biologist
Mike Riehle	Deschutes NF	District Fish Biologist
Tom Walker	Deschutes NF	District Fish Biologist
Bengt Coffin	Gifford Pinchot NF	Hydrologist
Gary Asbridge	Mt Hood NF	District Fish Biologist
John Dodd	Mt Hood NF	District Soil Scientist
Deigh Bates	Willamette NF	Hydrologist
Dave Halemeier	Willamette NF - Detroit RD	Hydrologist
Klamath/Siskiyou and Franciscan Provinces		
Workshop Participants		
David Fuller	Arcata BLM	Fish Biologist
Alan Olson	Klamath NF	Forest Fish Biologist
Gordie Reeves	Pacific Northwest Research Station	Fish Research Biologist
Jon Brazier	Rogue River - Siskiyou NF	Forest Hydrologist
Randy Frick	Rogue River - Siskiyou NF	Forest Fish Biologist
Connie Risley	Siskiyou NF Gold Beach RD	Hydrologist
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Mike McCain	Six Rivers NF Gasquet RD	Fish Biologist
Craig Tuss	USFWS	Field Supervisor
Additional Contributors		
Rich Walker	California Dept. Fish and Game	Modeler
Steve Cannata	California Dept. Fish and Game	Fish Biologist

Name	Agency Affiliation	Position
Don Elder	Klamath NF	Geologist
Juan de la Fuente	Klamath NF	Geologist
Rebecca Quinones	Klamath NF	Fish Biologist
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Clarence Hostler	NOAA Fisheries	Forester
Frank Bird	NOAA Fisheries	Field Supervisor
Sam Flanagan	NOAA Fisheries	Hydrologist
Adam Haspiel	Rogue River - Siskiyou NF	Fish Biologist
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Karen Kenfield	Six Rivers NF	Fish Biologist
Mark Smith	Six Rivers NF	Geologist
Tom Jimerson	Six Rivers NF	Ecologist

Appendix D. A current list of participants (and their agency association) in the Pacific Northwest Aquatic Monitoring Partnership.

Primary agency and tribal participants involved in shaping the planning document:

Aquatic-Riparian Effectiveness Monitoring Program: Steve Lanigan
Bonneville Power Administration: Jim Geiselman
Bureau of Reclamation: Michael Newsom
California North Coast Watershed Assessment Program: Scott Downie
Columbia Basin Fish and Wildlife Authority: Frank Young
Columbia River Inter-Tribal Fish Commission: Phil Roger
Colville Tribes: Keith Wolf
Idaho Fish and Game: Sam Sharr
NOAA Fisheries Northwest Fisheries Science Center: Steve Katz
Northwest Power and Conservation Council: Steve Waste
Oregon Department of Environmental Quality: Rick Hafele
Oregon Watershed Enhancement Board: Kelly Moore
Pacific States Marine Fisheries Commission: Bruce Schmidt
US Environmental Protection Agency: Dave Powers, Phil Larsen, Steve Ralph
US Forest Service – Region 6: Deb Konnoff
US Forest Service – Region 6: Deb Whitall (facilitator)
US Geological Survey: Dave Busch
Washington Department of Fish and Wildlife: David Johnson
Washington Department of Ecology: Steve Butkus
Washington Governor's Salmon Recovery Office: Steve Leider
Washington Salmon Recovery Funding Board and Interagency Committee for Outdoor Recreation: Bruce Crawford

Other agencies/organizations that have participated in Partnership efforts:

Army Corps of Engineers
Bureau of Land Management
California Department of Fish and Game
Confederated Tribes of Umatilla Indian Reservation
Oregon Department of Fish and Wildlife
Oregon State University
US Fish and Wildlife Service
US Forest Service – Fish and Aquatic Ecology Unit
US Forest Service – Region 5
US Forest Service Pacific Northwest Research Station
US Forest Service Washington Office
US Forest Service Stream Systems Technology Center
US National Park Service